

Initial Project Report
SMECO/Navy PEM Fuel Cell Demonstration
Contract #DACA42-02-C-0003

Site No. 1 and Site No. 2
Patuxent River Naval Air Station
Patuxent River, Maryland

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Southern Maryland Electric Cooperative, Inc.
Michael Rubala, Energy Services Supervisor
15065 Burnt Store Road
Hughesville, MD 20637

Points of Contact:

SMECO:

Mike Rubala, Energy Services Supervisor

Phone: 301-274-4338

E-mail: rubalam@smeco.com

Patuxent River NAS:

Mike Oliver, Utilities Engineer

Phone: 301-757-4723

E-mail: olivermg@navair.navy.mil

Energy Co-Opportunity

Brian Wierenga, Technical Support & Sales Representative

Phone: 231-861-7367

E-mail: wierenga@oceana.net

H-Power Corporation

Anita La Mendola, Technical Support

Phone: 514-956-2375

E-mail: alamendola@hpower.ca

Patuxent River Naval Air Station utility rates:

Electric (non-demand metered rate) \$.073/kWh

Natural gas (yearly average) \$0.90/therm

Fuel oil \$0.85/gallon

Stated rates include energy and distribution charges (demand and TOU rates do not apply).

Introduction

Southern Maryland Electric Cooperative (SMECO) and the Patuxent River Naval Air Station (PRNAS) agreed to work together to facilitate the demonstration of a Proton Exchange Membrane fuel cell (PEMFC) with support funding provided by the Construction Engineering Research Laboratory (CERL). The demonstration will hopefully advance the development and acceptance of fuel cell technology for small (2 to 10 kW) stationary applications. With experience gained from real world applications, we will be that much closer to achieving the goal of creating a highly-reliable distributed generation system. Fuel cell attributes should provide for a secure energy supply, reliable power for strategic applications, lower infrastructure costs, almost zero pollution, fuel use versatility, and the added benefit of on-site waste heat recovery.

Fuel cell specifications

Manufacturer:	H-Power Corporation, Inc.
Model/Designation:	RCU-4500-2/BETA RCU 4500 version 2.0
Product:	Residential co-generation unit
Unit power output:	LPG unit - 4.2 kW net, 10 kW peak for 15 minutes NG unit - 4.0 kW net, 10 kW peak for 15 minutes (Both units can provide 30 kW instantaneous)
Electrical output:	120/240 VAC, single phase, 60 Hz, 42 amps (max)
Fuel input:	LPG @ 17-20 Psig, NG @ 1 inch water column
Fuel to electricity:	LPG & NG 22-26%
Overall efficiency:	LPG & NG 33-66%
Co-generation output:	6.5 kW (22,185 Btuh) at 4.5 kW output
Dimensions (LxWxH):	63" x 45" x 56"
Weight:	3000 Lbs.
Storage conditions:	40-95°F (5-40°C), dry and clean environment
Configuration:	Grid independent with automatic transfer switch
Monitoring:	Remotely by phone/Internet
Emissions (full load):	Nox < 7 ppm, Sox < 1 ppm, CO < 1 ppm

Installation overview

SMECO will be installing two H-Power PEMFCs on PRNAS property. Site No. 1 (Quarters "Y") is a residential building occupied by Captain Charles Miller, USN, and his family. Site No. 1 PEMFC will be fueled by natural gas. We will be using the co-generation aspect of the fuel cell to supply the domestic hot water needs of the Miller family. The goal is to provide performance test data for typical residential applications.

Site No. 2 is the base Conservation & Environmental Education Facility (Building #1410) which represents more of an office environment. The Site No. 2 H-Power PEMFC will be fueled by propane gas. This application will help demonstrate the performance of a fuel cell in environments requiring good power quality with continuous high loading requirements unlike those of the typical residential load. This unit will, as well, incorporate a co-generation connection. Waste heat from the fuel cell will be used to heat the building via a hot water coil placed in the forced-air furnace.

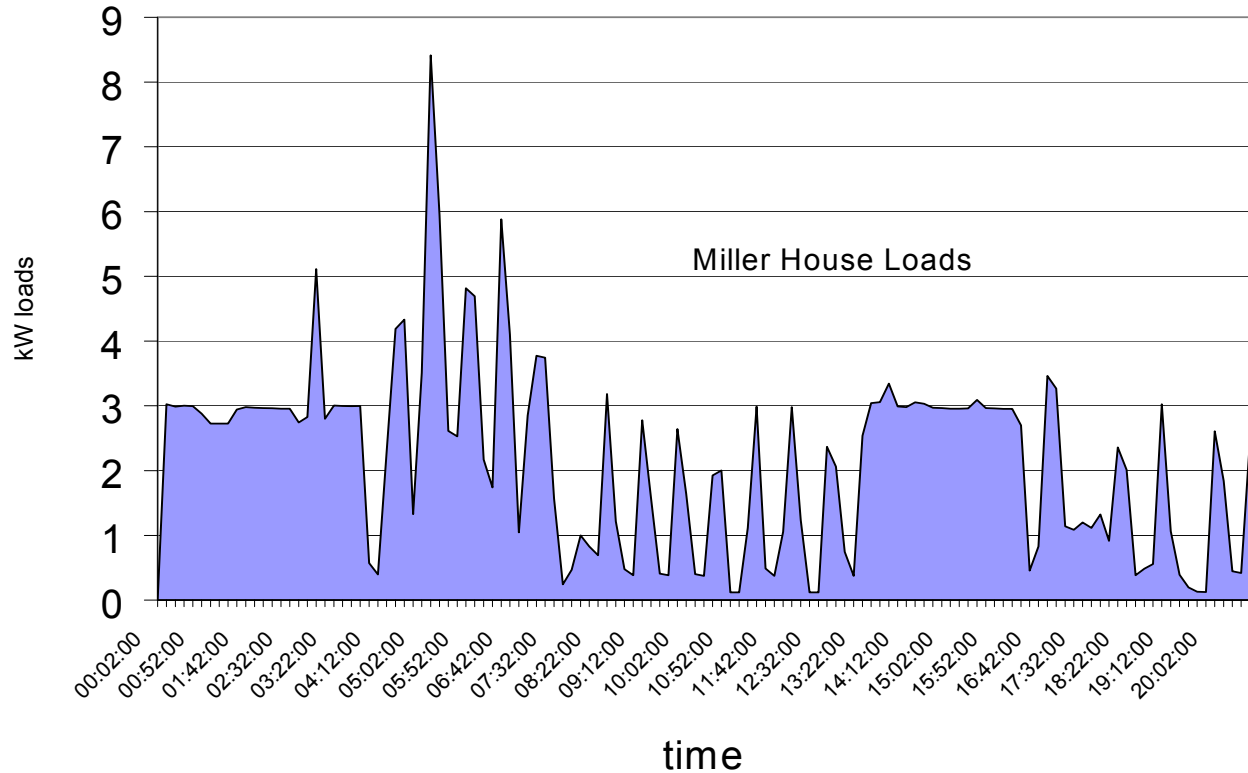
Both Site Nos. 1 and 2 H-Power fuel cells are designed to meet the 90 percent CERL performance requirement. H-Power will monitor both units via on-board computers and a landline connection to the Internet. Data will be collected concerning total operating hours, kWh and kW output, fuel consumption, waste heat generated, system availability, and maintenance performed.

Site No. 1 Information

Site No. 1 is a nominal 2,300 square foot residence located on the shoreline of the Chesapeake Bay. Natural gas is utilized by a low-pressure boiler, which supplies distributed hot water for heating and domestic potable hot water. Electric supplies all other appliances, including two 2.5-ton air conditioners. PRNAS personnel placed an amperage recorder on the main entrance cables serving the residence to determine the load profile during a peak cooling day.

The graph below illustrates a typical load profile during the cooling season. We expect the winter load profile to be approximately 60 percent less. We plan to use the fuel cell to replace 90 percent of the grid-supplied electric capacity. It is estimated the fuel cell will operate at about 60 to 70 percent capacity for a nominal six to seven hours per day, occasionally peaking close to 10 kW during the cooling season. Winter loads may peak at 10kW for

short durations, but for many hours the fuel cell will be operating at about 25 to 50 percent capacity.



Natural Gas PEMFC unit:

Energy savings estimated projections (90% availability)

Summer season fuel cell-supplied kWh (5 months)	6,957
Winter season fuel cell-supplied kWh (7 months)	3,110
Summer season grid-supplied kWh (5 months)	774
Winter season grid-supplied kWh (7 months)	344
Summer monthly available hot water generated	7.8 MMBTU
Winter monthly available hot water generated	2.3 MMBTU
Monthly average hot water fuel use (potable)	1.5 MMBTU
Projected avoided water heating costs per year (\$.90/Therm)	\$168.05

Total PEMFC electric generation cost	\$704.00
Total cost if grid had supplied electric exclusively	\$735.00
Net (savings) or cost	(\$31.00)
Avoided energy costs from co-generated heat use	<u>(\$168.00)</u>
Net energy dollar (savings) or cost	(\$199.00)

(PEMFC efficiency varies to load on stack; we assumed an average 1.8 kW hourly load during the summer and .6 kW hourly load during the winter with 24 -52 percent co-generation efficiency.)

Note: Unfortunately there will be substantial waste heat generated by the fuel cell that will not be utilized. We cannot use co-generated water in the boiler loop for space heating due to the high boiler loop temperatures. The projected maximum fuel cell output is around 140 degrees Fahrenheit. The boiler is a closed-loop system, which operates in the 160 to 185 degree Fahrenheit range and prohibits any pre-heat application from the lower temperature fuel cell waste heat. We used a total combined combustion and heat exchange transfer efficiency of 68 percent for potable hot water generation off the gas boiler.

Site No. 1 Installation

Base officials have decided to locate the fuel cell unit away from the residence. The picture below shows a small garage next to the house, which is where the unit is to be placed. This places the unit approximately 65 linear feet from the entrance point into the residence. The residence has a basement big enough to accommodate all the fuel cell connections for both wiring and plumbing. The basement area will house the automatic transfer switch and sub-panel, co-generation hot water storage vessel and circulation pump, feed water de-ionizer, and all back-flow valves. Several trenches will be dug between the residence and the fuel cell, to a depth of three feet, for the gas line, power and control wires, co-generation pipes, and the de-ionized water line.

General location of the fuel cell



Note: The old clothes line will be removed and the fuel cell will be placed about six feet from the garage window

Basement location where fuel cell controls are to be mounted.



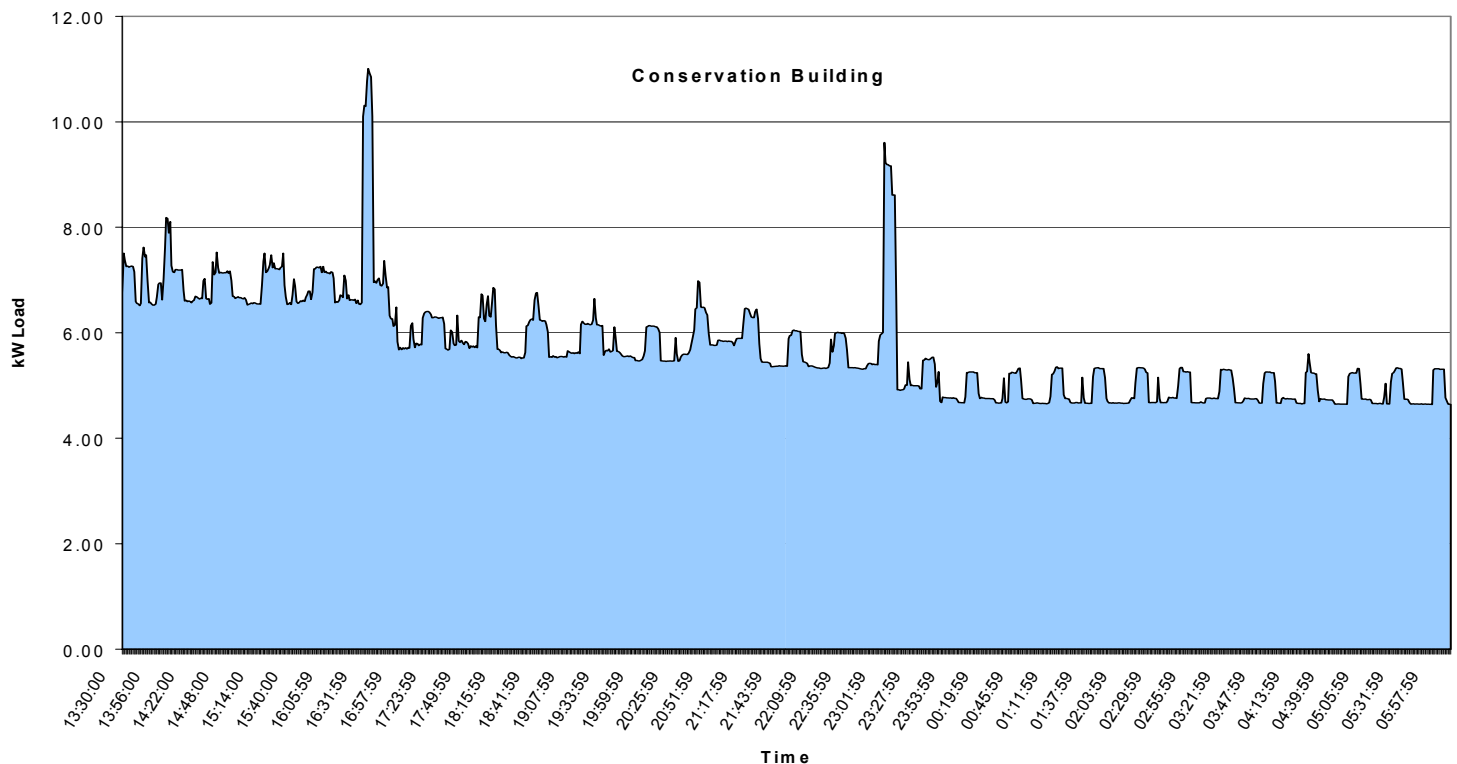
Location where co-generation connection to domestic water heater will be placed.



Site No. 2 Information

Site No. 2 is the base Conservation & Environmental Education building. It is a nominal 2,000 square foot, single story building, which contains office space, classrooms, and live animal displays. Natural gas is not available, so the fuel cell will be fueled by propane. The building uses an oil-fired hot air furnace for space heating and electric to power the 3-ton air conditioner, lighting, computers, and live animal displays. Co-generated hot water will be used for space heating via a water coil placed in the forced air furnace. The fuel cell will be supporting eight desktop computers, various printers, a large copier, central heating and cooling, lighting, and life support systems for the display animals. The facilities power quality requirements, reliability concerns, and a co-generation application will provide ample opportunity to test the fuel cell in a commercial-type environment.

PRNAS personnel recorded the representative load profile illustrating a peak cooling day with the building fully occupied. The graph shows a load profile consistently above the capacity of the installed fuel cell. We will not be able to replace 90 percent of the grid-supplied electric capacity but will be able to reduce the dependence substantially, even during peak cooling days. It is estimated the fuel cell will operate at 100 percent capacity for every hour the facility is open, with occasional peaks up to 10 kW. Based on yearly electric meter data, the fuel cell will be able to power the total electric capacity needs whenever the air conditioning system is off.



Propane PEMFC unit:

Energy savings estimated projections (90% availability)

Summer season fuel cell-supplied kWh (6 months)	15,292
Winter season fuel cell-supplied kWh (6 months)	8,161

Summer season grid-supplied kWh (6 months)	9,083
Winter season grid-supplied kWh (6 months)	907

Summer monthly available hot water generated	8.7 MMBTU
Winter monthly available hot water generated	3.8 MMBTU
Winter monthly average fuel oil use for space heating	29.3 MMBTU
Projected avoided space heating costs (\$0.85/gallon)	\$184.00

Total PEMFC electric generation cost	\$1,483.00
Total cost if grid supplied electric exclusively	<u>\$1,712.00</u>
Net (savings) or cost	(\$229.00)
Avoided energy costs from co-generated heat use	<u>(\$184.00)</u>
Net energy dollar (savings) or cost	(\$413.00)

(PEMFC efficiency varies to load on stack; we assumed an average 3.5 kW hourly load during the summer and 2.0 kW hourly load during the winter with 26 -52 percent co-generation efficiency.)

Note: There is a 50-gallon electric water heater located next to the furnace, but since the building primarily operates as an office/classroom facility, hot water use is marginal. Due to the expense of connecting the co-generated hot water off the fuel cell, compared to the energy offset, we felt it was not cost effective to pursue.

Site No. 2 Installation

Base officials decided to relocate the fuel cell from the original location at the rear of the building to the front. The new location would be in plain view of those that utilize the facility, especially children. SMECO also likes the new location. The location is right by the parking lot and only fifteen feet from the utility room. The utility room is the location for both the furnace and electric load center. We will locate the hot water coil in the furnace, and install the automatic transfer switch and sub-panel, circulation

pump, feed water de-ionizer, and all back-flow valves in the utility room, as well. All piping and wiring will be buried leading from the building foundation to the fuel cell. Relocating the fuel cell did increase the linear length of the propane gas fuel line by about 70 feet.

General location of the fuel cell



Note: A pressure-treated lumber foundation will need to be installed with gravel fill to accommodate the steep grade.

Utility room location for all fuel cell controls and co-generation installation



Official sign-offs

PRNAS officials and SMECO had to secure many permits and authorizations for the first-time installation of fuel cells on base. Listed below are the various departments or permits that had to be consulted or secured before construction could begin.

PRNAS Fire Department
Fuel Farm (propane use approval)
Environmental Office
Public Works Department
Utility (location and dig permits)
Cross-connection water evaluations
Housing Department
Project Review Board
Site Approval
Security
Plumbing and Electrical Inspector
Occupants' approval

Summary

SMECO and PRNAS recognize the need to load the fuel cell at Site No. 1 during the winter season. We are looking into electric heat alternatives for different rooms in the building. All cost estimates stated were based on laboratory performance criteria; real-world applications may differ substantially. Relocating both fuel cells from the original planned locations, as referenced in the grant proposal, have caused some headaches and additional installation costs.